In : Lee, Jeffrey A. and Zobeck, Ted M., 2002, Proceedings of ICAR5/GCTE-SEN Joint Conference, International Center for Arid and Semiarid Lands Studies, Texas Tech University, Lubbock, Texas, USA Publication 02-2 p. 113

Simulating the Martian Environment

K.M.Kinch, (e-mail: kjartan@ifa.au.dk), J.Jensen, (e-mail: jjensen@ifa.au.dk)
J.P.Merrison, (e-mail: merrison@ifa.au.dk), R.Mugford, M.N.Zadeh, A.B.Christensen, D.M.Grant, T.L.Jacobsen
All are: Institute of Physics and Astronomy, Aarhus University, Building 520, Ny Munkegade , DK-8000C, Denmark
K. R. Rasmussen, Department of Earth Sciences, Aarhus University, Building 520, Ny Munkegade , DK-8000C, Denmark (e-mail: geolkrr@geo.aau.dk)

Introduction

The Mars Simulation Laboratory at Aarhus University, Denmark is a newly established facility for laboratory simulation of the Martian environment. The main instrument is a recirculating wind tunnel, which runs at Martian surface temperature and pressure. Small particles of a Mars analogue soil are added to the wind stream. Several ongoing experiments use this facility for studying biological, chemical and aerodynamical aspects of the Martian environment. One example is a recently conducted study on triboelectric charging of dust suspended in the atmosphere, which showed some interesting preliminary results.

Design of The Wind Tunnel

The Mars simulation wind tunnel[1] at Aarhus University, is a re-circulating wind tunnel enclosed in a vacuum chamber. The vacuum chamber is cylindrical with a length of ~ 3 m and an inner diameter of 75cm. Inside the tank, the wind tunnel itself is a cylinder measuring 1.5 m in length and with a diameter of 40cm. The actual experiment is situated inside the wind tunnel. A fan placed at one end of the tunnel sets up a circulating wind. Gas runs through the tunnel, passes the fan, and returns on the outside of the tunnel in the space between the outer wall of the tunnel and the inner wall of the vacuum tank. Wind speeds may be varied from 0-20 m/s, which covers the most likely wind speeds on Mars. Good stability at very low wind speeds is an especially nice

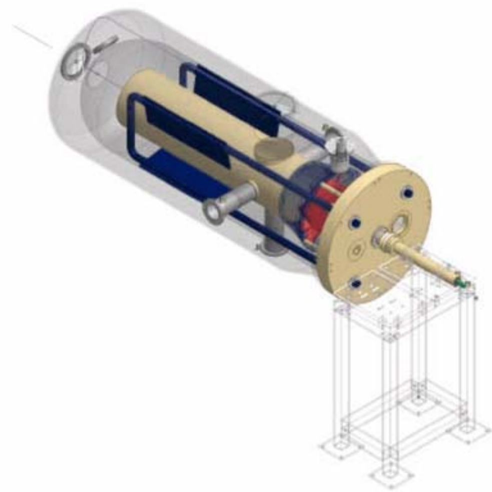

Figure 1. Design of the wind tunnel.

feature of the instrument. The chamber can be evacuated to 3×10^{-2} mbar, and then filled with any desired gas, normally CO_2. It is usually operated around 5-10 mbar. Tubes in the outer part of the tank allow cooling with liquid nitrogen down to a minimal temperature of ~ -120 ^{o}C
Dust is injected in the outer tank close to the fan and carried with the gas into the actual tunnel. It may be blown in by opening a valve, letting the pressure from outside push dust into the tank, this has the advantage that a lot of dust can be injected in a short time, but lets air into the tank, which increases the pressure and disturbs the composition of the gas in the tunnel. Alternatively dust may be injected from a vibrating container with a sieve in the bottom.
The dust used is a Mars analogue soil from Salten Skov, in central Jutland, Denmark. This analogue is believed to be close to Martian dust in terms of optical and magnetic properties. The soil is sieved to size <63µm and is dried at 110^{o}C before applying.
Wind speed and dust density is monitored with a laser Doppler anemometer (LDA). Here two coherent laser beams intersect to make an interference pattern. As a dust grain passes the stationary interference pattern light reflects off the grain in a series of pulses. The time between each pulse determines the speed of the grain (which is taken as a measure of wind speed). Dust density is estimated from the number of grains passing in a given time.

Triboelectric charging of dust

Charging and discharging of airborne dust on Mars has attracted some attention[2,3] as a possible hazard for a Mars lander mission, manned or unmanned. Dust deposition on solar panels and camera lenses may degrade these instruments, while charged dust may interfere with electronics and communication. As an example of recent activity in the wind tunnel we describe a preliminary experiment on the effect of charging on dust deposition
The experimental set up consisted of a glass plate 30 x 16.5 x 0.2 cm which was placed on top of two pieces of conducting foil 7x14 cm, these were separated by ~ 2cm. The one was grounded, as is the wind tunnel, and the other electrode was held at 200 volts. The plate was placed in the wind tunnel, holding it at an angle of 45^{o} facing in the direction of the wind, so that the foils were on the leeward side. The wind tunnel was run at a wind speed of 3 m/s for a period equivalent to

20 sols (Martian days) in terms of the amount of dust passing the experiment (the equivalent of 20 sols is reached in about an hour of actual time). After deposition the difference in deposition between the two electrodes was clearly visible to the eye. The absorbance at 532nm of the glass plate with deposited dust was measured at a series of points. The resulting curve is shown in Figure 2. There is a clear effect as the absorbance jumps from 0.35 to 0.5 at the edge of the charged plate.

A later series of measurements at a wind speed of 4.5 m/s investigated the dust deposition at different voltages from –200V to 200V. For all negative voltages the charged plate showed greater deposition than the grounded plate, this was also true for positive voltages above ~75V. Surprisingly however at positive voltages less than 75V the charged plate showed *less* deposition than the grounded one. A tentative explanation of this phenomenon suggests that there is a difference in the mean charge, size and/or number density between negatively and positively charged dust grains. If the negative grains react easier to an applied field, then the first effect of applying a positive voltage would be to repel negative grains, resulting in less dust deposition. Only at larger voltages would positive grains be attracted in large numbers.

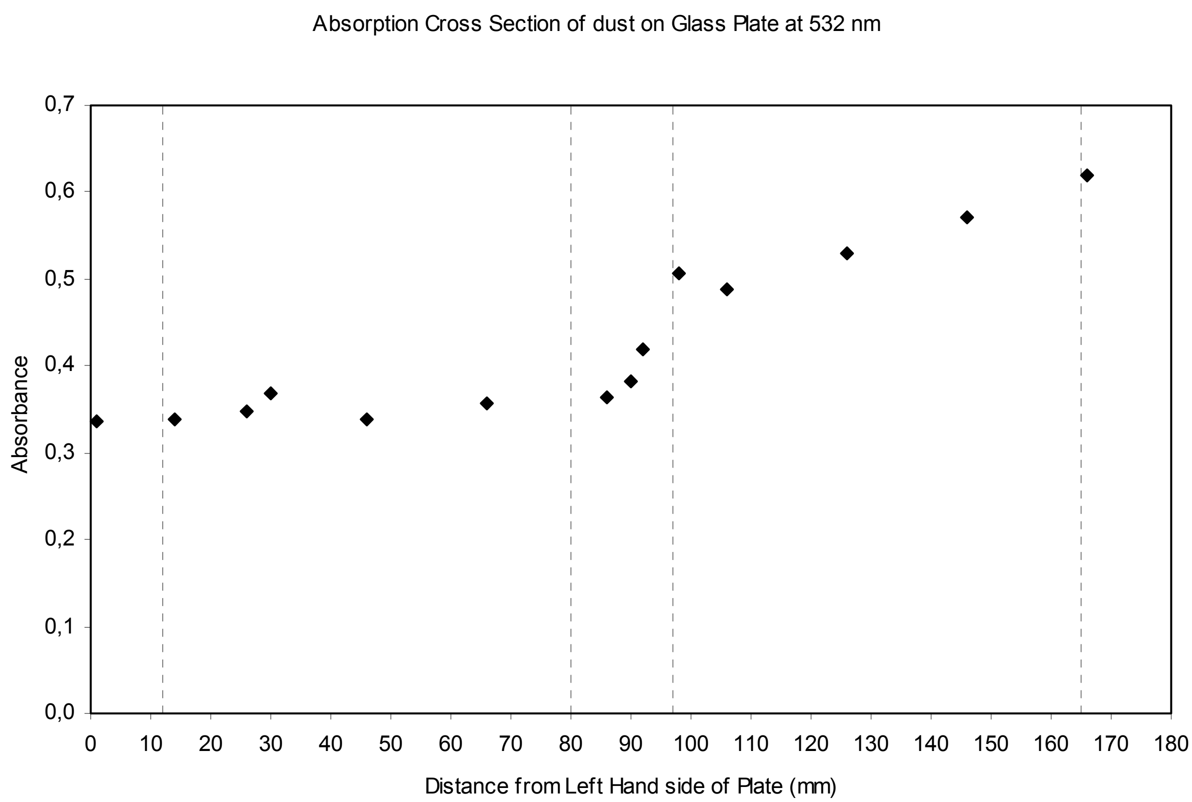

Figure 2. Preliminary measurement of dust deposition on charged and grounded areas. The grounded area begins at 12mm and ends at 80mm, while the charged area begins at 97mm and ends at 165mm.

Perspectives

While we stress that what is presented above are preliminary results, it would seem that this technique can be used to quantify the charge state of suspended dust and there is an interesting effect, which merits further investigation. Several other studies are planned or ongoing at the wind tunnel facility among them an investigation into magnetic attraction[5] of airborne dust, investigation of oxidation processes under Martian conditions and investigation into characteristics of aerodynamics on Mars.

References

Merrison, J.P. *et al.* 2002. Simulation of the Martian Dust Aerosol at Low Wind Speeds. *Journal of Geophysical Research (accepted).*

Farrel, W.M. *et al.* 1999. Detecting electrical activity from Martian dust storms. *Journal of Geophysical Research 104(2): 3795-3801*

Gross, F.B. *et al.* 2001. JSC Mars-1 Martian Regolith simulant particle charging experiments in a low pressure environment. *Journal of Electrostatics 53: 257-266*

Merrison, J.P. *et al.* 2002. Capture of Magnetic Dust in a Simulated Martian Aerosol: The Importance of Aerodynamics. *Planetary and Space Science (Accepted).*